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A Comparison of Tactile and Verbal Mobility Maps by Congenitally Blind and Adventitiously Blind Persons

Rajesh Malik

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ABSTRACT

A Comparison of Tactile and Verbal Mobility Maps by Congenitally Blind and Adventitiously Blind Persons

Rajesh Malik

The purpose of this experiment was two fold: First, it was decided to compare the effectiveness of tactile and verbal mobility maps; second, based on research which suggested that adventitiously blind persons perform better than congenitally blind persons on tasks related to space perception, it was hypothesized that the adventitiously blind subjects would perform better than the congenitally blind subjects on both the tactile and verbal map conditions. Eight congenitally blind and seven adventitiously blind subjects were tested with two tactile and two verbal maps and were asked to make walking route-like distance comparisons among locations on the maps. They were given a starting location and two target locations, and were asked to indicate which one of the two target locations named was closer to the starting location. The results indicated a trend toward superior performance on the tactile map as compared to the verbal map ($P = .067$). Adventitiously blind subjects did not differ significantly from congenitally blind subjects. The findings are explained with respect to cognitive factors.

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INTRODUCTION

The ability to explore one's neighbourhood surroundings, to travel freely in the city or village of one's habitation, or even the capacity to find one's way in a strange and previously unvisited land is undoubtedly important and necessary to conduct one's daily routine and essential for a meaningful and joyful existence. Persons with no visual impairment usually attain, during the normal course of development, the necessary skills and concepts to travel independently. Blind persons, on the other hand, face enormous difficulty and challenge to accomplish this task. Throughout the ages, visually impaired individuals depended on friends and relatives for their mobility, and those who were adventurous were left to stumble and grope their way about from one location to another. Since the early 1930's, and especially after the second world war, this situation has changed considerably. An increase in the research dealing with blindness has resulted in the establishment of graduate programs to train specialists in the orientation and mobility of the visually impaired (Welsh & Blasch, 1980).

A blind person encounters two major problems before any effective travel is possible, obstacle detection and avoidance, and orientation. The first of these has been widely researched and several substantial advances have been made in this area. A standard long cane is widely used for obstacle detection and avoidance and the introduction of dog guides has further enabled blind persons to travel without the fear of collision and thus minimize the risk of injury. In recent years, electronic devices have also been developed to detect obstacles and are used in conjunction with a long cane or a dog guide. The problem of orientation however, has received relatively little attention. The most common approach to orient blind persons in space is the use of verbal instructions, and to some degree, tactile maps are also employed. It has been assumed, rightly or wrongly, that the method most appropriate for orienting blind persons is verbal instructions and therefore, tactile maps are still in the developing stages. Sherman (1965) could find only three tactile city maps: one was of a German city, another was an outdated map of the subway system in London, and the third was of central London. Wiedle and Groves (1969) discovered in the survey of 367 blind individuals between the ages of 10 and 21 that 72% of those surveyed had little or no familiarity with tactile maps. This lack of emphasis on tactile maps may have been in part due to a number of studies published this century that compared the performance of blind and sighted subjects on tactual form and orientational tasks and concluded that blind subjects were inferior in these areas as compared to sighted subjects (Silvester, 1913; Worchel, 1951). It should be remembered however, that blind persons, until the introduction of the cane and dog guides, had little opportunity to explore their environment and their performance on the tasks related to orientation may have been poor not because of blindness, but because of severe exploratory restrictions. This point was further corroborated by the observations of Leonard and Newman (1967) concerning the map reading behavior of blind subjects and noted that inexperience, rather than blindness, accounted for poor map reading.

Systematic experimental research dealing with the effectiveness of verbal and tactile maps is almost nonexistent. In the last decade, however, some geographers, psychologists, and teachers of special education have made an attempt to experiment with various types of tactile maps and have tested a variety of tools for the production of maps. We shall first look at the various methods of tactile map production, then consider the types of tactile and verbal maps in use, and lastly, examine the research dealing with their effectiveness and usefulness.

Methods of tactile map production

Maps for blind persons differ from those for sighted persons in content and representation. Color of buildings and signs for example, are entirely useless on a tactile map for the totally blind. Usually, a tactile map is constructed with three types of symbols: line symbols to indicate linearity and direction, point symbols to represent landmarks, such as poles, trees, etc., and areal symbols to indicate textural patterns, such as green spaces, rivers, etc. Various ways of producing tactile maps have been developed and some of them are described below.

Nonreproducible maps. Chang and Johnson (1968) reported a kit consisting of a board equipped with Velcro, and various geometric shapes with a Velcro backing. The recommended use of the device was for the teachers of orientation and mobility to construct maps of city blocks to display to their students before or during a lesson. Although useful in its application for individual students, the maps produced by this method are not reproduceable for general distribution, and most important, the maps are very limited in scope.

Virko typing. This technique involves first drawing the map on a sheet and then dusting the page with resin powder which binds to the ink. When the page is heated, the resin powder melts and forms into a raised image. The image thus produced feels very sharp to the touch and the dusty powder sticks to the fingers and makes reading difficult (Kidwell & Greer, 1973).

Molded paper and plastic maps. In this category, maps are produced on a sheet of aluminum foil. Various types of sand-paper and pieces of wood and other objects are glued to the sheet to indicate texture and linear symbols. Multiple copies can then be produced by the process of vacuum forming. The quality of the raised maps is poor and the number of symbols that can be used effectively is also limited (Kidwell & Greer, 1973).

Polyvinyl chloride maps. This is perhaps the most versatile, but the most expensive of all methods as well. A weather-resistant and fireproof material is used which folds easily without leaving creases. The procedure involves heating resin powder into a core. During the heating phase, the master surface map, prepared from a photo engraved plate, applies a raised layer of pigmented vinyl that permanently affixes to the base. It is possible to produce a variety of point, line, and areal symbols at varying heights (Kidwell & Greer, 1973).

Computer aided maps. Gill (1973) developed a technique of map production which utilizes the current state of technology. First, the image of a map is traced with the coordinate table linked to a computer. A joystick is then used to position the desired symbols. Braille labels are typed by converting the computer keyboard into a grade one Braille keyboard. The final output is sent to a digital plotter. A negative master is produced in laminated plastic by a routing machine, guided by the computer. Finally, a positive copy is produced in epoxy resin. The initial cost of the computer is expensive, but it is a long term investment. The quality of the maps is excellent because a large number of point, linear, and areal symbols in different sizes can be produced.

Embossed maps. A number of map-making kits are available for the construction of maps either on an aluminum sheet, which can then be used for vacuum forming, or simply on paper. The kits contain tools for embossing line, point, and areal symbols (James, 1975). The kits are inexpensive and the method of map production is easy to learn. Although the symbols are not as varied as in the polyvinyl chloride technique, embossing kits enable satisfactory maps of campuses and cities to be reproduced for general use.

Types of tactile maps

Three different types of tactile maps are currently in use: one-layer maps, multiple-layer maps, and modular maps. The first category of maps is produced on one sheet of paper, usually a 28 cm by 28 cm square, the size of a vacuum forming plastic sheet. Single layer maps are best suited for portraying small city sections. Multiple-layer maps are also printed on the same size of Braille sheets as discussed above, but more than one sheet is used. Each successive layer presents different information about the same area. For example, layer one can present the outline of an area, layer two can show street patterns, walkways, etc., layer three can include some transit routes served in the area. Braille labels can be included on the front or the back of any of the layers. Multiple-layer maps have the capacity to represent large environments, such as entire cities, campuses, etc. (Bentzen, 1977). Finally, Day (1983) has reported a new type of map called modular map. A large area can be represented by modular maps using more than one sheet, each sheet providing entirely different information. The sheets can be used separately or glued together and used as separate quadrants of the same map. Each type of map is usually accompanied by a Braille key, which lists all symbols used on the map, or by a cassette, which describes the techniques to use the map effectively. So far, no research has been conducted to determine what type of map, produced by what kind of map producing system, is most appropriate for what types of circumstances.

Types of verbal maps

Two types of verbal maps have been described in the literature. The first is known as the sequential route map which describes a set of directions to travel from one location to another. Commonly used in mobility training procedures, this map is limited in scope because a person using it is restricted to traveling one route to get to a desired location and if detours are ever required, the person cannot derive another route from the set of route instructions. The second category of maps is known as the district maps (Blasch, Welsh, & Davidson, 1973). A district map describes a section of a city and presents an overall picture of the area. The route derivation process is left to the person concerned. The limitation of this type of map is that large environments, such as campuses and entire cities, are too cumbersome to describe. Both route and district maps can be presented either on tape or in Braille.

Research on tactile and verbal maps

Only one research paper was discovered which reported a comparitive study on the effectiveness of tactile and verbal maps (Leonard & Newman, 1970). Subjects in three different conditions were asked to travel to certain objectives. Condition 1 was taped verbal instructions, describing several routes, Condition 2 was a set of Braille instructions, and in the third condition, a tactile map was employed. No statistical data were recorded and only subjective information regarding the subjects performance was made available. It was indicated that the subjects who performed well in the Braille instructions and the tactile map conditions tended to be young and were familiar with tactile maps. No age differences existed in the verbal map group subjects. In another study (Langbine, Blasch, & Cholmerse, 1981), six blind subjects were given extensive training in the use of verbal maps in preparation for their participation in an orienteering program. Subjects were required to traverse a 1-kilometer area and pass through check points. It was reported that all participants successfully completed the required task. No information was given about the nature of the verbal map and the term "successful completion" was left unexplained.

Research concerning tactile maps is similarly poor in that only subjective data are available, but it is more extensive than verbal map research and provides some useful information. Bentzen (1972) asked six independent blind travelers, unfamiliar with the campus the study used, to trace a map and then travel to three different buildings while passing through a number of check points. Two subjects completed the task without any intervention, but the remaining four required some assistance at least once during the experiment. Five subjects reported the map to be useful and stated their preference for tactile representation over verbal instructions, which they routinely used. In another study by Bentzen (1977), 18 independent blind travelers were asked to participate in a project whose aims were to train mobility specialists to instruct blind travelers in the use of tactile maps, and to provide feedback to the map makers. A simple map of the Metropolitan Boston Transit Authority (MBTA) was constructed by using a tactile embossing kit. The same line symbol was employed in the representation of all four routes served by the Rapid Transit System. A key was provided in Braille and in large print. A complex map of Boston and Cambridge was produced in four layers and included residential and shopping areas, street patterns, green spaces, water bodies, universities and their main entrances, museums, etc. The map was accompanied by a tape instructing the readers in the use of the map. The participants were asked to plan and travel some unfamiliar routes and report back to the instructors. Subjects preferred the Boston/Cambridge map to the MBTA map because of greater information content and because of the varied use of symbols. Subjects reported having greatly benefited from the experience. Some stated that the map clarified the city structure for them. By using the map, some successfully aided sighted friends in unfamiliar areas while driving.

James and Swane (1975) trained four blind subjects in the use of a multiple-layer embossed map of two bus routes and reported that subjects successfully traveled in the prescribed areas. James and Armstrong (1975) developed an embossed map of a shopping center in four layers and evaluated the map by training five subjects in the use of the map. The investigators asked their subjects a total of 36 questions to determine the participants performance on the map. They obtained a mean of 23.3 correct responses. In the second evaluation phase, 2 independent blind travelers, unfamiliar with the shopping center, were asked to travel to three different shops. Once again, the task was successfully carried out.

In a most ambitious project, Kidwell and Greer (1973) asked their 8 subjects at MIT to recommend what type of campus map they desired. The students presented the investigators with a list of objects and locations and a map was produced by the polyvinyl chloride technique. The students evaluated the map and reported a number of problems with it. Some symbols were found to be indiscriminable from other symbols, and a few objects and locations, as desired by the students, were not included on the map. The experimenters decided to produce a revised map with improved legibility. Although the revised map still contained some undesirable problems, the subjects found the map to be of help in planning new routes to the frequently traveled locations.

Leonard and Newman (1967) asked six congenitally blind adolescents, who were familiar with maps, to trace a map and travel to certain objectives. While on the route, they were stopped twice, and asked to plan a detour. The subjects received 1 point for completing the detour task unassisted, half a point for some assistance, and no points for requiring specific instructions. The authors felt that the subjects were successful in carrying out the required task, although no subject could solve both detours, at least without some assistance.

To summarize, the studies dealing with the effectiveness of verbal and tactile maps have not reported any objective data and in all studies reviewed, no systematic attempts were made to compare their effectiveness, nor was there any effort devoted to understand what type of map is more suitable in what type of circumstances. Another problem has been the use of different types of maps produced by various types of methods. The effectiveness of the type of map and the type of technology used in their production has also not been evaluated. Finally, to date, about 10 point, 10 linear, and six areal symbols have been found to be distinctly different, but further research is indicated since studies so far have usually employed various methods of producing these symbols, and the testing of the symbols has usually been carried out in isolation, not in real maps (Welsh & Blasch, 1980).

Map reading experience

Berla, Butterfield, & Murr (1976) tested 36 blind subjects on a pseudo-political map and asked them to locate six shapes, shown to them separately. They selected nine subjects who located the largest number of shapes correctly and required the least amount of time to do so, and nine subjects who located the smallest number of shapes correctly and required more time than other subjects, and classified them as good and poor map readers. A video-taped analysis of their map reading behavior revealed clear distinctions between the two groups. The good map readers indulged in a systematic exploration of the entire map, traced lines more often than poor map readers, traced around the objects of interest in one continuous motion, beginning and ending at a fixed point. Poor readers, on the other hand, explored the map haphazardly while inspecting objects of interest. They did not trace around objects in a systematic fashion, while tracing, fell off lines more often than good readers, and tended to follow intersecting lines. According to the authors, it was difficult to characterize the poor map readers' behavior because they engaged in a lot of irrelevant activities. Thus, it appears that the variable of map reading skills is important in any research on tactile map reading.

Berla & Butterfield (1977) have shown that training blind individuals can improve their map reading abilities. In two experiments conducted by the authors, the subjects, based on their pretest scores, were divided into trained and untrained groups. The untrained group was then taught some basic map reading skills including proper line tracing techniques, keeping an index finger on a fixed point as a reference and tracing with the index finger of the dominant hand; features analysis, picking out salient characteristics of objects. On the post test, both groups were required to locate shapes (presented on cue cards) on a political map. Results indicated that the trained group located significantly more objects correctly and required significantly less time than the untrained group. Although this difference between the two groups could be attributed to the trained group's longer experience with the tactile map, Berla & Butterfield (1977) show that training blind persons in map reading skills could be substantially beneficial.

Research on blindness

There is some evidence that congenitally blind and adventitiously blind perform differently on tactual form and orientational tasks. Leonard (1966) postulated that adventitiously blind subjects should benefit more from tactile maps than congenitally blind persons because of the former s experience with visual maps and because they understand such concepts as the properties of scales. Wiedle & Groves (1969) noted that congenitally blind subjects had considerably more difficulty in reading maps than did adventitiously blind subjects. Numerous other studies have been published in other areas which corroborate these findings.

Silvester (1913) tested congenitally blind, early blind (vision loss before the age of three), and late blind (vision loss after age three) on a form discrimination task. The subjects explored a board with spaces in which various geometric shapes could be fitted. They were then required to insert geometric blocks into appropriate recesses on the board. The results showed that the more visual experience the subjects had, the fewer were their errors. Silvester concluded that the late blind subjects had had sufficient visual experience to be able to use visual imagery.

Worchel (1951) conducted a series of experiments to examine the role of vision in form perception and form discrimination. In one such experiment, congenitally blind, adventitiously blind, and sighted subjects were given two wooden blocks in each hand. Once they had familiarized themselves with the pattern of the blocks by turning them over in their hands, they were required to look at four geometric wooden blocks and were asked to select one that would be constructed by the synthesis of the blocks they had previously explored. The congenitally blind subjects made more errors than the adventitiously blind subjects, who in turn performed worse than the sighted subjects. Also, there was a positive correlation between the age of blindness onset and performance for the adventitiously blind subjects. In another experiment (Worchel, 1951), subjects performed a form recognition task and were asked to verbally discribe the forms and then draw them. As before, the performance of the sighted subjects was superior to the two blind groups and the congenitally blind were significantly worse than the adventitiously blind. Worchel concluded that tactile perception was inferior as compared to visually aided tactual perception, and that the more visual experience a person has the better his perceptual abilities.

By using the form combination task of Worchel, Drever (1955) confirmed Worchel's findings. At the same time, he also asked his early blind, late blind, and blindfolded sighted subjects to learn a geometric pattern made by using pegs on a board. The pattern was then rotated 180 degrees and the subjects were required to recreate the original pattern. The early blind and the blindfolded sighted performed worse than the late blind subjects. The inferior performance of the sighted was ascribed to their inexperience with performing such tasks haptically. It was suggested that previous visual experience aided the late blind in organizing tactual information more efficiently than the early blind.

Juurmaa (1973) argued that the superiority of performance by the adventitiously blind and the sighted in Worchel's (1951) and Drever's (1955) experiments could be due to these subjects' greater familiarity with the objects used in the experiments, such as a square, circle, ellipse, etc. He proposed that if subjects were presented forms that were equally unfamiliar to all subjects, the difference in performance would disappear. O'Connor and Hermelin (1975) conducted an experiment employing familiar and unfamiliar objects to compare the performance of blindfolded sighted and congenitally blind subjects. In the former case, both groups performed equally, but when they were presented a model of a human hand (a familiar object) in a variety of orientations, and were asked to indicate whether it was a right hand or a left hand, the blind group's performance was inferior to the blindfolded sighted group's performance. These findings supported Juurmaa's (1973) assertion that visual experience is advantageous only when the perception of familiar objects and forms is in question. This may be taken to mean that congenitally blind, adventitiously blind, and the sighted do not differ in their spatial ability, but differ with respect to their capacity to use visual cues when they are familiar with particular spatial forms. However, the experiment of O Connor and Hermelin (1975) did not distinguish between adventitiously blind and congenitally blind subjects; therefore, no conclusions concerning spatial differences between them can be drawn from these data.

Schmitt (1978) presented unfamiliar nonsense forms to congenitally blind, adventitiously blind, blindfolded sighted, and sighted subjects and asked them to indicate whether they were the same in shape, size, and orientation. The sighted subjects performed the best, followed by the adventitiously blind and the blindfolded sighted whose performance did not differ, and the congenitally blind scored significantly less than all other groups.

In a series of related experiments, Cleaves and Royal (1976; 1979), required subjects to perform mental transformations of finger mazes of various complexities. Once the congenitally blind, adventitiously blind, sighted subjects had succesfully learned a maze, they were asked to make pointing responses while the maze was imagined as originally learned, and while imagining the maze to be oriented in different directions in space. The congenitally blind subjects performed worse than the other two groups in all conditions. The longer the subjects had vision, the better was their performance. The authors concluded, "it is possible that early visual experience in orienting to objects in the environment provides a kind of exact spatial localization training through visual reafference that cannot be accomplished through the other senses, when there is an absence of vision" (Cleaves & Royal, 1979, p. 19).

After reviewing the experiments conducted between 1920 and 1956 on maze learning, Schmitt (1978) concluded (although not overwhelmingly) that the adventitiously blind subjects performed better than the congenitally blind subjects. In general, they made significantly less errors and required fewer trials to learn the maze than did the congenitally blind. Visual experience, it was argued, afforded these persons an advantage in spatial ability over persons not having any visual experience.

In a related area of cognitive mapping, similar conclusions have been reached by Rieser, Lockman, and Pick (1980). In their study, congenitally blind, adventitiously blind, and sighted subjects were asked to make two types of triadic comparisons among locations in a highly familiar environment: route (walking) and geometric (Euclidian) comparisons. No group differences were noted under the route-like comparison condition, but in the geometric distance condition, the congenitally blind performed significantly worse than the adventitiously blind, who were inferior to the sighted in turn. It was argued that the blind subjects had no difficulty in the former condition because they had traveled in the test environment frequently and were familiar with the routes among the locations tested, but their cognitive map of the environment was not as well structured as those of the sighted subjects. They also stated that the congenitally blind had difficulty in shifting from functional to Euclidian distance judgments. The superior performance of the sighted group to that of the adventitiously blind group, it was suggested, was due to the specific visual experience with the space tested in the experiment. The difference between the adventitiously blind and the congenitally blind on the other hand, indicated that a prior general visual experience is also essential.

To examine the flexibility of cognitive maps of blind individuals, Rieser, Guth, and Hill (1982) tested congenitally blind, adventitiously blind, and sighted subjects in a novel and a familiar environment. The subjects were first given an orientation session to six objects in the environment and then were required to perform two experimental tasks: first, they were led to one of the objects in the room (the locomotive task) and were asked to point rapidly and accurately to randomly named objects; and second, remaining at the starting location, they were asked to imagine (the imagination task) that they were standing at another location and were required again to point to other locations in the room. In the novel environment condition, the sighted and the adventitiously blind groups needed less time and made significantly less errors than the congenitally blind group. During the locomotion task, the congenitally blind subjects reported having considerable difficulty in computing the location of each object, but the other two groups did not experience this difficulty. The imagination task, however, presented difficulty to all three groups. This notion was supported by the data which indicated that all subjects made more pointing errors as compared to their baseline measures. The authors proposed that the early blind subjects appear to be deficient at perceptual updating while traveling from place-to-place. The results obtained in the familiar environment condition indicated no group differences. In the subsequent interviews, the congenitally blind subjects revealed that they had often traveled among the test locations before and were simply familiar with the directions of each object. The experimenters concluded that these subjects had memorized the direction of every target location from the test position. This confirmed the assertion of Rieser, Lockman, and Pick (1980) that the cognitive maps of the congenitally blind are less well structured than those of the adventitiously blind.

It is clear from the studies reported in this section that vision appears to be an important factor in the interpretation of spatial relationships, and that having some prior visual experience is advantageous as indicated by the superior performance of the late blind subjects. However, there is no agreement among investigators whether adventitiously blind perform better than congenitally blind because of a general superiority of spatial ability, or because they are highly familiar with some visual forms. Jones (1975) maintains that during development, a general motor system functions to integrate spatial information from various senses. Congenitally blind children are restricted in motor activity and this difference between the activity level of the adventitiously blind and the congenitally blind results in the differential performance on spatial tasks.

Hart and Moore (1973) have described the stages of cognitive map development. The spatial representation of large scale environments proceeds in three stages: the egocentric stage, the fixed and partially coordinated stage, and the coordinated and spatially integrated stage. Due to the behavioral and motor restrictions imposed by others (parents) and self-imposed restrictions, blind persons are limited in sensory exposure to environmental information and for this reason, perceptual deficits begin to arise and retard the proper development of cognitive maps.

Indeed, the major criticism of the studies comparing spatial abilities of the early and late blind subjects which rely upon pointing responses and drawing is that they assume falsely that congenitally blind use these modes of communication in everyday functioning. Furthermore, they assume that these abilities are well-developed in the congenitally blind and can be compared meaningfully with those of sighted and late blind subjects. The congenitally blind may be deficient in drawing and pointing accurately to unseen objects, but not in spatial ability. It is clear that some other dependent measures should be used which would enable meaningful comparisons of the spatial abilities of the congenitally blind, adventitiously blind, and sighted persons.

The present experiment

The following experiment was designed to test two ideas: first, it was decided to compare the effectiveness of tactile and verbal maps; second, it was hypothesized that adventitiously blind subjects would perform better than congenitally blind subjects. The latter prediction was based on the rationale that adventitiously blind persons have had some exposure to visual maps and that this experience may generalize to tactile and verbal maps. Furthermore, research dealing with blindness points to the fact that adventitiously blind subjects perform better on spatial tasks than their congenital counterparts.

Two tactile maps, similar in layout and construction, and their verbal descriptions were presented to a group of congenitally blind and a group of adventitiously blind persons. The subjects were asked to make route-like (walking) functional distance comparisons between a starting location and two target locations. Specifically, they were asked to indicate which of the two target locations named was closer to the point of origin in question. Since distance judgment is an important part of map interpretation, it was assumed that if the subjects interpreted the maps correctly, they would be able to make correct distance estimates among locations.

A methodological note. The primary aim of this experiment was to compare the effectiveness of two tactile and two verbal maps on the dimension of functional distance judgments among actual locations on the maps. A question concerning the comparability of these two varied modes of representation can legitimately be raised. For this purpose, extreme care was taken in preparing one of the two tactile maps based on the instructions accompanying the map-making kit supplied by the American Printing House for the Blind. The other tactile map was constructed and provided by the above mentioned institution.

The verbal maps were the product of a collaboration between the experimenter and two qualified orientation and mobility instructors, who were skilled and trained in the construction of such instruments, and who utilized them readily to instruct blind students on daily basis. Furthermore, the following four types of instructions were incorporated on the advice of Blasch, Welsh, and Davidson (1973). (1) egocentric orientation. These types of instructions require describing the environment in relation to the person by using such concepts as right-left, in front of and behind, etc. (2) Topocentric orientation. This involves depicting the relationship between the person at a given point in the environment and various landmarks, objects, and other areas in the surroundings. (3) Cartographic orientation. According to these instructions, information about the street organization, building patterns, and other relevant geometric information is provided: (4) Polarcentric orientation. Finally, the whole environment is described based on the compass directions.

In this way, both tactile and verbal maps were considered to be of acceptable quality. Although no objective test was employed to determine whether the tactile and verbal maps were comparable in quality, nevertheless, it was a first attempt of its kind to conduct an an experiment in which these two different modes of representing environmental information to blind persons could be compared meaningfully. A skeptical person will not be satisfied with the above explanation and indeed, the comparability question can always be raised since one can never be certain whether these two entirely different categories of objects have attained comprability.

Method

<u>Subjects</u>

Eight congenitally blind subjects, with a mean age of 26.5 years and a standard deviation of 16.8, and seven adventitiously blind subjects, with a mean age of 32.7 years and a standard deviation of 11.3, participated in the experiment in return for a fee of 8 dollars (see appendix F for subject information). Nine of the subjects were male and 6 female. The subjects for the experiment were recommended by two mobility and orientation instructors at the Montreal Association for the Blind, who were familiar with the subjects traveling capabilities. All subjects were considered to be independent travelers and had undergone formal mobility training. The participants had extensive background in the use of verbal maps, but had no familiarity with tactile maps. However, at least three congenitally blind subjects reported having some familiarity with raised-line drawings and graphs. One of the congenitally blind and 3 of the adventitiously blind subjects used dog guides as the primary means of travel, and the remaining subjects relied on a standard long cane for traveling purposes. All eight congenitally blind persons were limited to no more than light perception since birth. One adventitiously blind individual had partial vision until the age of 20, and the remainihg six subjects in the group had full vision for at least the first seven years of their life, but by the time of the experiment had no more than light perception.

Materials

The materials used in the experiment consisted of two tactile maps (T1 and T2), and two verbal maps (V1 and V2). A graphics and tactile kit developed by the American Printing House for the Blind (Barth, Berla, Davis, & Kundiff, 1981) was used in the construction of the two tactile maps. The kit contained seven point, seven linear, and four areal symbols, which were pretested and were found to be discriminable by 95% of the blind subjects tested (Barth et al., 1981). A variety of tools were included in the kit for embossing the symbols on a 28 cm by 28 cm square sheet of aluminum. Multiple copies of the maps were reproduced by the process of thermoforming, which works by means of a heat vacuum pump. The pump sucks the plastic sheet down on to the aluminum master, thus creating raised images on plastic sheets. T1 was supplied with the kit and portrayed an area with two north-south streets and three intersecting east-west streets (See appendix A). Six different point symbols were used to represent traffic lights, stop signs, a playground, a picnic area, stairways, and entrances to buildings. Four linear symbols indicated road with sidewalk, sidewalk or an alley, fences, and building outlines. Finally, three areal symbols represented wooded areas, a pond, and a parking lot. Braille labels identified streets and buildings on the map. A key was prepared which listed all symbols and was presented on a separate sheet. T2 was constructed for the purpose of this experiment and was similar in design and layout to T1, but some modifications were deemed necessary to create a different environment (see appendix B). The main alterations included changes in the names of some streets and buildings, juxtaposition of some buildings, and introduction of some new locations. As in T1, T2 also portrayed an area consisting of two north-south and three intersecting east-west streets. The maps were also similar in terms of the number of buildings and the symbols used to indicate various locations.

The verbal maps were prepared with the assistance of two mobility instructors, who were skilled in the preparation of these types of maps and used them regularly in training blind individuals for mobility and orientation. The maps were recorded and were presented on a cassette. V1 was a verbal description of T1, and likewise, V2 was a verbal representation of T2. Appendices A and B show line drawings of T1 and T2, and appendices C and D contain descriptions of V1 and V2, respectively.

Procedure

Each subject was tested in individually scheduled sessions lasting about 1.5 to 2.5 hours with one tactile and one verbal map in the same session and a break of five minutes between presentations. Four congenitally blind and three adventitiously blind subjects were tested with T1 and V2, and four congenitally blind and four adventitiously blind subjects were presented T2 and V1. A complete counterbalancing was not possible because of unequal sample sizes and because more than a necessary number of subjects had been tested with T1 and V2 when a major methodological change was introduced which required the use of T2 and V1. Therefore, five subjects were tested with T1 first and four subjects with T2 before being tested with the respective verbal maps. On the other hand, two subjects were given T1 and three participants were tested with T2 before the verbal condition.

In the tactile map condition, the subjects were shown both the map and its accompanying key and were asked to explore the map until they felt comfortable. Once they indicated their readiness to commence the experiment, they were asked to locate seven previously selected symbols. This was undertaken to assertain whether the subjects could interpret the symbols shown on the maps. 80% of the subjects carried out the required task without error. In the case of three subjects who made at least one error, they were told of their mistake and were urged to relocate the symbols. On the second attempt, all subjects performed satisfactorily. The verbal maps were presented on a cassette and the recording lasted about 5 minutes. The subjects were asked to listen to the entire tape once, and were informed that they would be free to replay the verbal information at any time during the experiment. The orientation phase of the experiment for both the tactile and verbal maps lasted about 20 minutes.

The experimental procedure was as follows: Six locations were chosen from T1 and T2 in such a way as to include at least one location from each city block shown on the maps. The locations chosen were identical for T1 and V2, and the positions used in T2 were used in V1. The locations were entrances to buildings and various other locations on the maps (see Appendix E for a list of locations). The subjects were given the names of three locations and were asked to make functional (walking) distance judgments. They were given a starting position, location A, and two target locations, B and C. They were required to indicate which of the target positions was closer in functional distance to the starting location A. It was emphasized that they should not make geometric comparisons, rather, they should look for the shortest route from the starting point to the target locations. An example of a typical question would be: "From the pharmacy entrance, which of the two locations is closer, the parking lot entrance from Park Avenue, or the picnic area?" A total of 20 distinct triadic combinations were possible based on six locations, and were presented to each participant. The questions for T1 and V1 were the same, and likewise, the same for T2 and V2. The procedure of functional distance comparison was modified from the procedure employed by Rieser, Lockman, and Pick (1980).

In the present experiment, one pilot subject was tested with the procedure of Rieser, Lockman, and Pick (1980). This congenitally blind subject, who had extensive background in reading tactile maps, found it difficult to remember the names of three locations while reading the map and determining functional distances among locations. Therefore, to avoid forced errors resulting from the experimental procedure, the experimental task was simplified. In the experiment of Rieser, Lockman, and Pick (1980), the subjects tested were quite familiar with the experimental space and they were tested on their existing knowledge of that space; thus, the number of tasks those subjects performed was considerably less than what was asked of the subjects in the present experiment.

At the completion of the experiment, the subjects were asked which map, tactile or verbal, they preferred. They were then informed about the exact nature of the project and were thanked for their participation.

Results

The task of distance comparison was likened to a task of signal detection in which an experimenter presents stimuli below and above the threshold level of a given stimulus dimension. In such an experiment, nearly all subjects perceive certain stimuli (above threshold) and on the other hand, nearly all subjects fail to perceive certain stimuli (below threshold). The experimenter is interested only in the responses of intermediate stimulus range. Similarly, in the present study, it would be natural to expect that some triadic comparisons would be of extreme difficulty to nearly all subjects and some responses would be judged accurately by nearly all participants. Therefore, it was decided to eliminate such responses and consider only those of intermediate difficulty.

There were two possible ways of discarding the most difficult and the least difficult triads. One way was to consider the actual metric distances among locations on the tactile maps and eliminate those having very small and very large distances. For this purpose, the distances on the two tactile maps were measured and the differences between the longest and the shortest paths for each triad were used

in the subsequent analysis. A correlation between distance on the map for each triad and overall performance (tactile and verbal combined) was then calculated. For T1V1, $r = .25$ ($p > .05$) and for T2V2, $r = .29$ ($p > .05$). In other words, no significant relationship between distance and overall performance was found and therefore, the method of metric distance for the elimination of easy and difficult triads was not appropriate.

The second procedure involved considering the subjective decisions of the participants; that is, discarding those triads which almost all subjects judged accurately (easy) and those which nearly all subjects judged incorrectly (difficult). Based on a previously set arbitrary criterion, 5% of the triads from the bottom and 5% from the top of the distribution of each map were eliminated. Thus, two triads from each map were discarded and all subsequent analyses were performed on 18 possible correct responses.

Before proceeding further, some comments concerning the performance of one subject are necessary. This individual, a congenitally blind female, completed the task on the tactile map successfully, but was unable to carry out the experimental task on the verbal map, despite listening to the instructions of V1 twice. She reported that she could not form a mental image of the environment and thus would not be able to answer any questions. She further stated that in her daily travel, she could not use verbal instructions (district maps) efficiently. Due to a limited number of blind subjects available for the experiment, it was not possible to discard the data of even one individual. It was reasoned that if this person had performed the required task without any information (this would have been the case had she been pressed upon to answer any questions), her performance would be expected to equal chance level performance, and therefore, she was assigned a score of nine on the verbal map.

Although there wasno significant difference between the ages of the two groups ($t = 0.80$, $p > .05$), a significant correlation between the ages and overall performance (tactile plus verbal) for the adventitiously blind subjects was found ($r = .8$, $p < .05$). However, the correlation was not significant for the congenitally blind subjects ($r = .08$, $p > .05$). A significant correlation for the former group was totally unexpected. Furthermore, the correlation between performance and the length of visual experience was not significant. It was decided to use the age of subjects as a covariate in the subsequent analyses.

Table 1 presents the means and standard errors of the mean for the congenitally blind and adventitiously blind under both map conditions. A 3-way analysis of covariance with two between factors and one within factor was carried out on the number of correct responses (see Table 2). The first between-subject factor was the two groups of subjects, congenitally blind and adventitiously blind, the second between-subject factor was the different stimulus material, one group receiving T1 and V2 and the other getting T2 and V1. The within-subject factor was the type of map, tactile and verbal. The analysis revealed no significant main effects or interaction effects. However, a tendency toward a difference was noted for the within-subject factor ($p < .07$). As predicted, the subjects tended to perform better on the tactile map than on the verbal map. Table 1 presents the adjusted means for both groups under tactile and verbal map conditions.

Following this, 4 1-tailed, independent T tests with

Table I

Real and Adjusted Means[a] and Standard Errors[b] of Correct Responses for Congenitally and Adventitiously Blind Subjects on Tactile and Verbal Maps

	Map Type		
Subjects	Tactile	Verbal	Total
	Real Means and Standard Errors		
Congenitally Blind	13.0 (1.6)	9.9 (0.6)	11.4 (0.9)
Adventitiously Blind	13.3 (0.8)	11.7 (1.5)	12.6 (0.8)
Total	13.2 (1.2)	10.9 (1.1)	
	Adjusted Means		
Congenitally Blind	13.2	10.1	11.7
Adventitiously Blind	13.1	12.2	12.7
Total	13.15	11.15	

[a] Maximum score = 18

[b] Presented in parentheses

Table 2

3-Way Analysis of Covariance Summary Table

Source	SS	df	MS	F
Between Subjects				
Type of Blindness	4.55	1	4.55	.37
Map Combination	31.38	1	31.38	2.53
Type of Blindness x Map Combination	1.95	1	1.95	.16
1st Covariate	19.86	1	19.86	1.60
Error	124.22	10	12.42	
Within Subjects				
Map Type	33.37	1	33.37	4.13 *
Map Type x Type of Blindness	7.38	1	7.38	.92
Map Type x Map Combination	7.38	1	7.38	.92
Map Type x Blindness x Map Combination	41.00	1	41.00	1.88
Error	88.75	11	8.06	

* $p = .066$

alpha correction were performed, comparing the adjusted means of congenitally blind and adventitiously blind groups on both the tactile and merbal maps. The means were compared with the chance level performance of 9 correct responses. Both groups performed significantly higher than the chance level on the tactile map ($t = 2.9$, $p < .025$, and $t = 2.8$, $p < .025$ for the congenitally blind and adventitiously blind groups, respectively). The T values for the verbal map conditions were not significant.

A further analysis of the data indicated that 11 of the 15 subjects scored higher in the tactile map condition than they did in the verbal map condition. Six congenitally blind and five adventitiously blind subjects had better scores in the tactile condition than the verbal condition. Fourteen of the 15 subjects reported their preference for the tactile map over the verbal map. One adventitiously blind subject who preferred the verbal representation had 18 correct responses on the verbal map and 12 correct responses on the tactile map.

It was predicted that the adventitiously blind subjects would perform better than the congenitally blind subjects. However, this hypothesis was not confirmed as the main effect for the first between-subject factor was not significant (see table 1 for the adjusted means).

The results also showed that varying the environment so that one group of subjects received T1 and V2 and another group received T2 and V1 failed to affect the subjects' performance. This was confirmed by the failure of the second between-subject factor to reach significance.

A 2-way Anova was carried out to determine whether the performance of the subjects differed with respect to the order of presentation of the stimulus material; that is, whether the presentation of the tactile map, before or after the verbal map, affected performance. The analysis failed to reveal a significant main effect for the between-subject factor (the groups receiving different order of stimuli) ($F = 1.7$, $p > .05$). The mean for the subjects receiving the tactile map first was 12.2 and the mean for the verbal map following the tactile map was 10.3. The mean for the subjects receiving the tactile map in the second instance was 16.2 and the mean for the verbal map in the first instance was 11.5.

Finally, to determine whether there was any relationship between performance and distance on the maps, four correlations were computed separately for each of the four maps. No significant correlations were observed. For T1, $r = .16$, for T2, $r = .35$, for V1, $r = .23$, and for V2, $r = .11$ ($p > .05$ for all correlations).

Discussion

The first hypothesis.

The first and the foremost aim of this experiment was to investigate the performance of blind subjects on tactile maps and compare that with the performance on verbal maps. Although the results of the analysis of covariance did not reach significance, the probability level was close to the .05 level, that is, .067. Moreover, only the two tactile means for the congenitally blind and adventitiously blind were significantly different from chance, but not the verbal means, and the fact that 11 of the 15 subjects performed better on the tactile condition than on the verbal condition, suggests a strong trend towards a superiority of the tactile maps. It is likely that with a larger sample, the results would have reached the required level of significance, but as noted earlier, there was only a limited number of English-speaking congenitally blind subjects available for the experiment; therefore, the sample size could not be increased.

This experiment was mainly concerned with a comparison and determination of the effectiveness of tactile and verbal mobility maps and no consideration was given to classifying the types of errors made under both conditions. Upon completion of the experiment, all attempts to categorize the errors coherently did not succeed. In future research, however, it would be instructive to compare the types of errors made under the tactile and verbal map conditions. This may be accomplished by asking subjects to describe exactly the route they decide to take from one location to another.

For both T1 and T2, and V1 and V2, there was no relationship between performance and the actual distances on the maps, as all correlations were not significant. In other words, the intuitive notion that the subjects should perform better when distances are large as compared to when the triads have small distances, was not confirmed.

A variety of reasons can be offered to explain why we might expect performance to be superior with tactile maps as opposed to verbal maps. What appears in the following paragraphs is highly speculative.

Bentzen (1972) found in her study that when blind subjects were required to travel in an unfamiliar environment with the help of a tactile map, they successfully carried out the task and declared at the end of the study that they preferred the tactile representation over verbal description, which they utilized in daily travel. They provided three reasons for their choice: (1) Tactile maps are easy to refer to; (2) they provide more information than do verbal maps; and (3) tactile maps create a mental image of the routes. Let us first consider the question of mental imagery.

The internal representation of space is likely to be either motoric or spatial. Cognitive encoding of spatial information from tactile maps is probably more reliable and is likely to be less ambiguous than the information provided by verbal maps, because the latter requires an extra step of semantic encoding, not necessary in tactually presented maps. The cognitive image of an environment based on verbal maps would vary from person to person, according to the individual's ability to remember small and intricate details, and mostly, on the capacity to create reliable mental images from words only. Tactile maps provide a physical analog image of the environment and as a person perceives the map, he or she is able to internally represent that particular environment. But verbal maps do not have the advantage of a physical analog image and the person is required to construct a mental image of the environment for himself or herself. Thus, tactile maps involve more perceptual elements in the image construction process than do verbal maps. The possible superiority of the tactile maps may be due to the differences in the image construction process of perceptual and cognitive tasks. This idea is supported by the behavior of one congenitally blind subject in this experiment. This individual expressed an inability to construct a mental image of an environment from verbal descriptions. She had no experience with tactile maps, yet her performance exceeded the chance level. She repoorted that she usually required help from sighted persons for orientation to an environment before she was able to travel there independently. In such a case, tactile maps could be used to orient a person before any travel is undertaken and minimize the need to depend on others for one's mobility.

Verbal maps are more likely to be ambiguous than tactile maps and it may be more difficult to describe some information in words than representing it physically. For instance, while describing the location of a shop at a street corner, it may be easier to depict its exact situation on a tactile map than to describe it verbally. Words may not be able to indicate exactly how far from the corner the shop is located. Curved paths and complicated geometric forms and structures may be perceived better when tactually represented. An example of ambiguity may be given here. While an adventitiously blind subject was listening to the instructions of a verbal map which described the area in question as a rectangle, bounded on each side by a street, followed by the description of the locations in the area, the subject misinterpreted the instructions and remarked that a few locations lay outside the rectangle. The experimenter had to intervene to clarify the confusion.

The second reason for the possible superiority of tactile maps can be termed its "hypothesis testing" capability. A tactile map enables a blind person to confirm or disconfirm hypotheses about route selection. He or she can trace the map to discover whether a desired route is longer or shorter than the other possible routes to a location of interest, but a verbal map does not allow this flexibility. A person must work out this exercise in his or her mind and he or she is no longer able to demonstrate to himself or herself, the various possible decisions regarding route selection.

The third reason for the possible superiority of tactile maps is their capacity for greater content than verbal maps. By including a large amount of detail on verbal maps, however useful, one runs the risk of rendering the maps cumbersome, incoherent, and unuseable. But in the case of tactile maps, this problem is satisfactorily resolved by producing the maps in multiple layers (Bentzen, 1977).

<u>The second hypothesis.</u>

According to the second hypothesis of the experiment, adventitiously blind subjects were expected to perform better than their congenitally blind counterparts. The results did not lend credence to this supposition. I shall offer two provocative explanations to account for a lack of difference between the two groups, although the data of the experiment do not directly address these conjectures; they merely indicate that the groups did not differ in performance.

As noted before, various investigators have attributed the differences on spatial tasks between the congenitally blind and the adventitiously blind, and between the blind in general and the sighted to the differences in the amount of visual experience or to a lack of it (Silvester, 1913; Worchel, 1951). Juurmaa (1973) and Jones (1975) have used the huypothesis that these differences may best be explained by the differences in motor and behavioral activity levels of the congenitally blind and the adventitiously blind. Adventitiously blind persons understand, as do the sighted, spatial relationships by directly observing (visually) the spatial relations between objects and locations. They learn to interpret maps and can appreciate extended space (vista). Since the behavioral activity of the congenitally blind is restricted either by the parents and/or self-imposed, from an early age, and the fact that they are rarely taught how to interpret space by the use of models and maps, their ability to represent and understand space may become retarded. If they receive training in space perception and mobility, they may be able to achieve the same level of performance as the adventitiously blind, and perhaps, the sighted. The last two decades have seen the development of formal orientation and mobility programs for the visually impaired and because of it, blind persons have begun to receive instruction in effective and independent travel. Currently, training is available in Canada, the United States, and some European countries. It may be inferred from the foregoing that the congenitally blind of today, at least in the United States and Canada, are better equipped to interpret spatial relationships than the congenitally blind of the past, and those living in other countries where no orientation and mobility training is available. In recent years, some studies have failed to find differences in the spatial ability of the congenitally blind and the adventitiously blind (e.g. Balles & Lambert, 1986), and between the blind in general and the sighted (e.g. Landau, Gleitman, & Spelke, 1981).

Cassey (1978) conducted an experiment in which blind and partially sighted subjects were required to construct a model of a familiar school campus. Although the models of the blind subjects tended to be not as well structured as those of the partially sighted, some blind individuals produced well structured models. These subjects were more independent in their travel than those producing less coherent models.

Landau, Gleitman, and Spelke (1981) compared the performance of a congenitally blind child with those of sighted children. The experimental task involved the subjects to travel to previously untraveled routes in a room with four objects. The performance of the congenitally blind equaled that of the sighted chilren of the same age (two and a half years). The authors concluded that the capacity of the congenitally blind children to interpret geometric relationships may not differ from the sighted children of comprable age.

The hypothesis whether mobility training aids the congenitally blind to better understand spatial relationships can be tested by comparing the performance of subjects who have had extensive mobility instruction with those not receiving any training, perhaps in other countries. There may be a relationship between the amount of orientation and mobility training and performance on space-perception tasks. In the present study, the subjects were all considered to be independent travelers and had undergone formal mobility training. Consequently, the congenitally blind subjects used in the experiment may have the same level of spatial ability as the adventitiously blind subjects.

The second explanation concentrates on the idea that the congenitally blind may be able to compensate for a lack of visual experience by employing the method of elaborative rehearsal to classify and categorize spatial information effectively in order to retain it in long-term memory. They may require a considerable amount of time to achieve the same level of performance as that of the adventitiously blind persons. Cronin, McLaren, and Campbell (1983) tested this hypothesis. Although they did not include a group of adventitiously blind subjects, their results are still of immense interest.

Seventeen sighted subjects performing visually, 27 sighted performing tactually, 10 blind, and 9 partially sighted subjects explored 10 objects. After 48 hours, all participants returned when they were asked to make a comparison between the previously explored objects and new distracting objects. They were asked to indicate the previously familiar objects. In the initial exploration phase, the sighted subjects performing visually required significantly less time than the other groups. In the test task, the sighted performing visually required significantly less time than the other groups and the blind subjects needed significantly more time than the other three groups, although the performance of the blind and the sighted performing visually did not differ. It was concluded that by increased concentration and attention, blind subjects were able to compensate for a lack of visual experience and perform optimally.

In the present experiment, latency to perform the experimental task was not recorded. Even if the congenitally blind had practiced the method of elaborative rehearsal, no time differences between them and the adventitiously blind groups may have emerged because the subjects were not matched for Braille-reading skills. From the subjective impressions of the experimenter, no such differences were seen between these two groups of subjects. It should be emphasized here that adventitiously blind persons, if blinded after high-school age, do not use Braille to the same extent as the congenitally blind persons and this leads to a large discrepency between them on the variable of Braille-reading.

<u>Practical implications</u>

Blasch, Welsh, and Davidson (1973) proposed that auditory maps may be more useful and effective in providing information to the blind traveler than tactile maps. They put forward several reasons to back their argument. According to them, tactile maps are difficult to reproduce, contain less information than auditory maps, and require persons to have well-developed haptic skills. Lederman and Kinch (1979) raised the possibility that the tactile system may not be suitable for encoding spatial information, since acquiring sequential information from a tactile map makes it difficult for the visually impaired to gain appreciation of the whole. Attitudes such as these have contributed to a limited amount of research on the effectiveness of tactile maps and has resulted in apathy on the part of the mobility specialists to incorporate tactile maps into their teaching plans. The present experiment tends to demonstrate for the first time, in an experimental design, that the tactile map, a medium with which most blind individuals have little familiarity, was a better form of representing environmental information than the verbal map, a method blind individuals rely upon for daily travel and a method greatly overemphasized in mobility training. One should be cautious in the interpretation of the results of this experiment, however, since the overall analysis failed to reach the .05 level of significance. Further experimentation is needed to establish clearly the trends the current investigation points to.

The research by Berla and Butterfield (1977) further strengthens the argument of the usefulness of tactile maps for the visually impaired by showing that proper training can improve blind individuals' map reading skills. Bentzen (1972, 1977), Barth et al. (1981), and Day (1983) have provided findings that indicate that tactile maps may not be as difficult to reproduce as originally thought by Blasch, Welsh, and Davidson (1973).

In the present experiment, the subjects were required to indicate which one of the two locations named was closer to a point of origin. The method of distance comparison allows us to make certain conclusions about a person s knowledge of an environment, it is however, an indirect way of gaining such information. Future research should look at more direct ways of tackling this problem, perhaps by asking subjects to trace the routes on a map and indicate their choices.

In the present experiment, the time spent by the subjects to explore the tactile maps or to replay the information of the verbal maps was not recorded. It is possible that factors such as attention span, the tendency to answer questions without devoting sufficient time to understand the material, or impatience with the experimental procedure, may affect the results. Another important and relevant point is the quality of both tactile and verbal maps used in the experiment. Although an attempt was made to produce high quality tactile maps in line with the guidelines provided by the American Printing House for the Blind (Barth et al., 1981), and to prepare effective verbal maps with the assistance of qualified mobility instructors, who were skilled in the construction of verbal maps, the question whether the quality of tactile and verbal maps in the experiment was equal can still be raised. Future research should pretest these maps, perhaps by asking blind persons and mobility instructors to rate them on such variables as the amount of useful information, legibility and comprehensibility etc.

Another important point should be noted at this juncture. Proficiency in tactile map reading does not guarantee effective travel. Good mobility and orientation skills include logical planning strategies, self-confidence, a low level of anxiety about being outdoors, and a lack of dependence on others for one's mobility (Langbine, Blasch, & Cholmerse, 1981). Therefore, future research should also compare the effectiveness of tactile and verbal maps in real-life situations in which subjects can be asked not only to demonstrate their map reading performance, but also to demonstrate their traveling abilities with the maps.

In short, the time has come to redress the mistake of ignoring tactile maps for so long and realizing the benefits they may render to blind pedestrians. The tactile maps have the potential of enriching the daily lives of the visually impaired travelers by widening their circle of travel. Thus, tactile maps can make the world at large available to blind persons at their finger tips.

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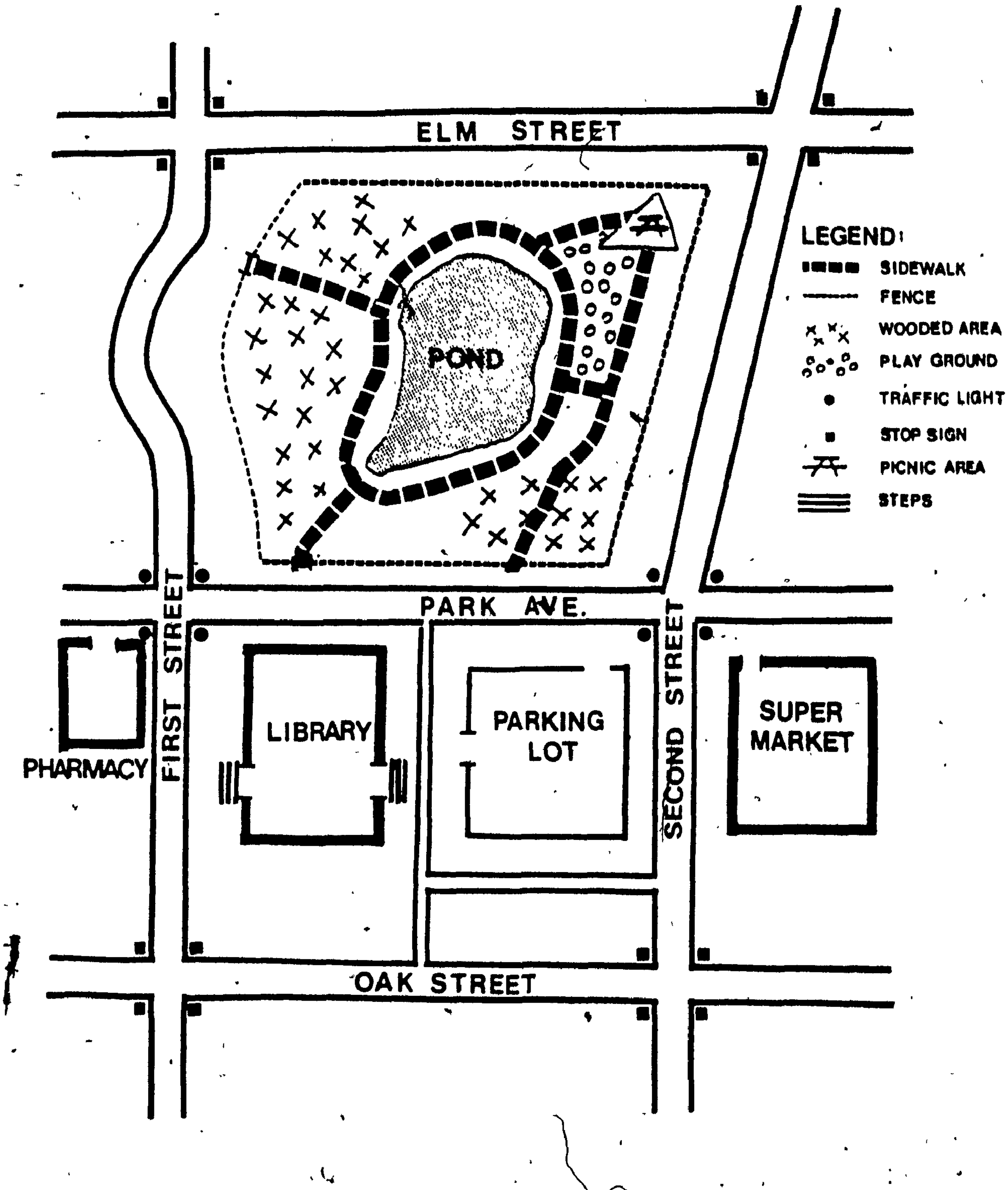
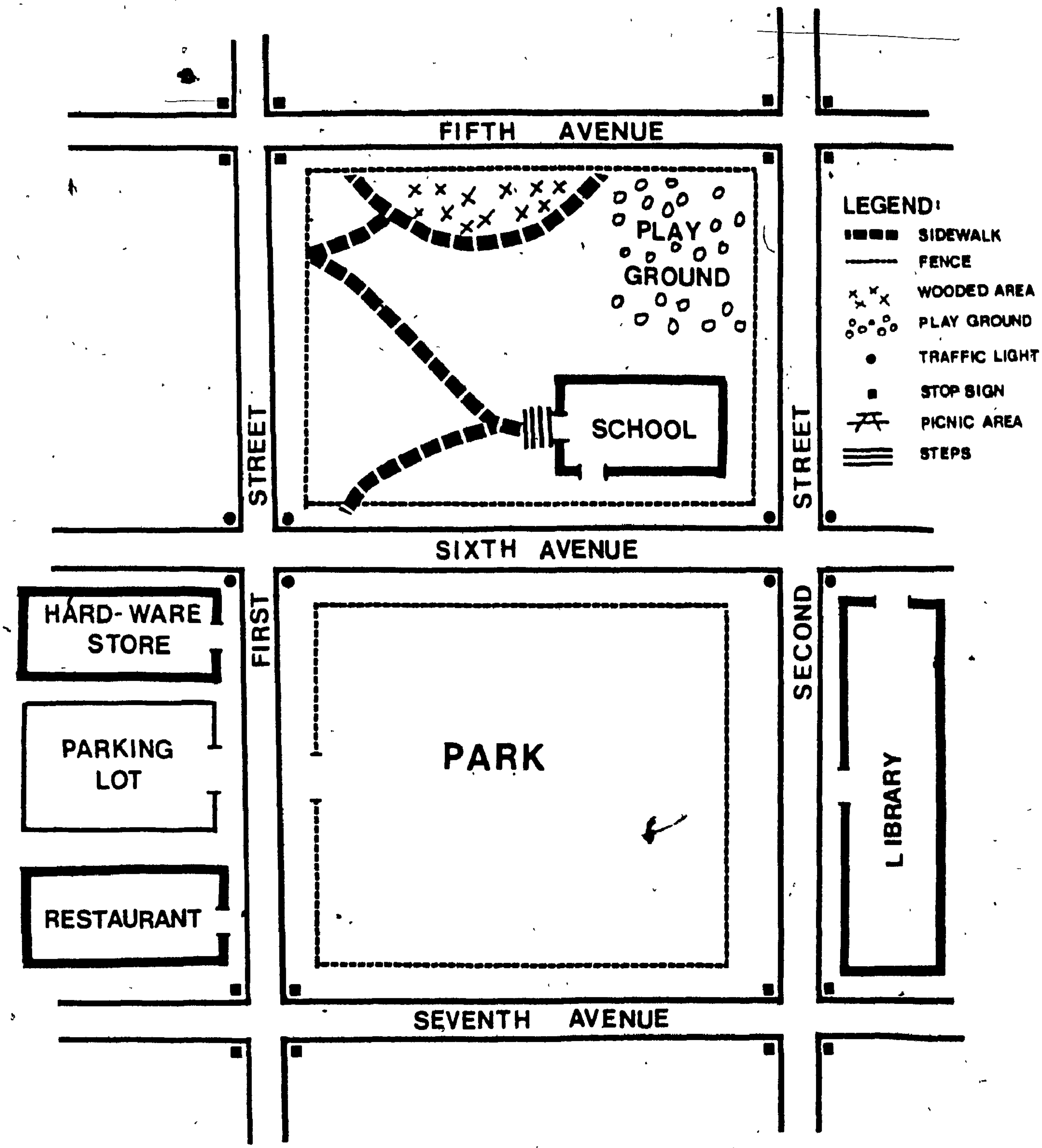
Appendix A

Tactile Map 1 (T1)


ELM STREET
POND
LEGEND:
SIDEWALK
FENCE
WOODED AREA
PLAY GROUND
TRAFFIC LIGHT
STOP SIGN
PICNIC AREA
STEPS
PARK AVE.
FIRST STREET
SECOND STREET
PHARMACY
LIBRARY
PARKING LOT
SUPER MARKET
OAK STREET

Appendix B

Tactile Map 2 (T2)


FIFTH AVENUE
PLAY GROUND
SCHOOL
STREET
STREET
LEGEND:
SIDEWALK
FENCE
WOODED AREA
PLAY GROUND
TRAFFIC LIGHT
STOP SIGN
PICNIC AREA
STEPS
SIXTH AVENUE
HARD-WARE STORE
FIRST
PARKING LOT
RESTAURANT
PARK
SECOND
LIBRARY
SEVENTH AVENUE

Appendix C

Verbal Map 1 (V1)

VI

The area we are going to look at is a rectangle, bounded on the west by 1st Street, and on the east by 2nd Street. Three east-west streets lie perpendicular to 1st and 2nd Streets. They are: Elm Street to the north, followed to the south by Park Avenue, and Oak Street forms the southern boundary of this area. Parallel to, and in the center of 1st and 2nd Streets, there is an alley, which extends from the south side of Park Avenue to the north side of Oak Street. East-west blocks are twice as long as the north-south blocks, and all blocks have sidewalks. There are two traffic lights in this area, both located on Park Avenue; one at the intersection of 1st Street, and the other at the corner of 2nd Street. The remaining four intersections have stop signs. They are: 1st Street and Elm Street, 2nd Street and Elm Street, 1st Street and Oak Street, and 2nd Street and Oak Street. North of the intersection of Park Avenue, 1st Street curves slightly towards north-west, but it curves back towards north-east when it meets Elm Street.

Traveling east along the south side of Park Avenue, there is a pharmacy, whose entrance is located just west of the intersection of 1st Street. East of the traffic light, there is a library, which is not accessible from Park Avenue. Instead, the steps leading to the library can be found in the middle of the block, on the east side of 1st Street. As you proceed east on Park Avenue, east of the library, you will come to an alley, and if you turn right here, there is another set of stairs leading to the library, on the western part of the alley, in the center of the block. East of the library and the alley, there is a parking lot, which is fenced on all sides, but has two entrances. The first entrance is on the south side of Park Avenue, west of the intersection of 2nd Street, and the second entrance is on the eastern part of the alley across from the stairway which leads to the library. South of the parking lot (or behind it), there is another alley extending from the alley described above, to the west side of 2nd Street. Continuing eastward along Park Avenue, just east of the intersection of 2nd Street, there is a supermarket, whose entrance is located at the corner of Park Avenue and 2nd Street.

The area between the north side of Park Avenue, and the south side of Elm Street, and between the east side of 1st Street and the west side of 2nd Street, is fenced on all sides. In the center of the block, there is a pond surrounded by a sidewalk which forms a circle around the pond. The pond is accessible from any of three entrances. The first is situated at the 10 o'clock position in relation to the pond, on the east side of 1st Street, just south of Elm Street. The second entrance is at the 8 o'clock position, on the north side of Park Avenue, just east of 1st Street. The third entrance is at the 4 o'clock position on the north side of Park Avenue, just west of 2nd Street. As you enter either of these three entrances, you will be on a sidewalk which leads to the pond. A wooded area occupies the ground west of the pond between Park Avenue and Elm Street. A smaller wooded area exists in the south east corner of the enclosed rectangle, just as you enter from the 4 o'clock position entrance. In the north-east corner, at the 1 o'clock position in relation to the pond, there is a picnic area, and two sidewalks lead up to it from the pond. One from the 2 o'clock position, and the other from the 3 o'clock position. In between these two sidewalks, located just east of the pond, is a playground. Finally, the picnic area is also connected with the 4 o'clock position entrance by a winding sidewalk.

Appendix D

Verbal Map 2 (V2)

V2

The area we are going to look at is a rectangle, bounded on the west by 1st Street, and on the east by 2nd Street. Three east-west streets lie perpendicular to 1st and 2nd Streets. They are: 5th Avenue to the north, followed to the south by 6th Avenue, and 7th Avenue forns the southern boundary of this area. East-west blocks are twice as long as the north-south blocks, and all blocks have sidewalks. There are two traffic lights in this area, both located on 6th Avenue; one at the intersection of 1st Street, and the other at the corner of 2nd Street. The remaining four intersections have stop signs. They are: The corner of 5th Avenue and 1st Street, 5th Avenue and 2nd Street, 7th Avenue and 1st Street, and finally, the intersection of 7th Avenue and 2nd Street. Traveling north on the west side of 1st Street, there are three locations betwen 7th Avenue and 6th Avenue. Just north of 7th Avenue, there is a restaurant, and located next to it is a parking lot. The third location is a hardware store, just south of the intersection of 1st Street and 6th Avenue. If you proceed north on the east side of 1st Street, you will encounter a large park, which takes up the entire distance between 7th and 6th Avenues. The park also covers the distance between 7th and 6th Avenues on the west side of 2nd

Street, and between 1st and 2nd Streets on the south side of 6th Avenue, and on the north side of 7th Avenue. The park is fenced on all sides and the entrance to the park is located half way up the block on the east side of 1st Street.

A public library can be found on the east side of 2nd Street between 7th and 6th Avenues. The entrance to the library is located half way up the block between 6th and 7th Avenues on the east side of 2nd Street. The library can also be entered from its second entrance, situated on the south side of 6th Avenue, just east of the intersection of 2nd Street.

The area between 5th and 6th Avenues on the east side of 1st Street, and on the west side of 2nd Street, and between 1st and 2nd Streets, on the north side of 6th Avenue, and on the south side of 5th Avenue, is taken up by a school and its playground. Fenced on all sides, the school is situated in the center of the block and faces west or 1st Street. The playground is in the north-east corner of the block. The school has two entrances. The first entrance is on the north side of 6th Avenue, just east of the intersection of 1st Street. The second entrance is on 1st Street, just south of the intersection of 5th Avenue. Upon entering either of these entrances, you will be on a winding sidewalk, leading to the steps of the school. In order to reach the playground from the 1st Street entrance, turn north (left) and follow the sidewalk which will curve to the east. As you are walking, there will be a wooded area on the left. The wooded area covers half the distance of the block between 1st and 2nd Streets. As the wooded area ends, you will find yourself in a large open space, this is the playground, which covers the remaining half of the distance between 1st and 2nd Streets.

Appendix E

A List of Locations Used in T1 and V2, and T2 and V1

A List of Locations Used in T1 and V2, and T2 and V1

Locations used in T1 and V2

1. The pharmacy entrance,
2. The center of the library,
3. The entrance to the parking lot from Park Avenue,
4. The entrance to the supermarket,
5. The center of the western wooded area,
6. The picnic area.

Locations used in T2 and V1

1. The parking lot,
2. The park entrance,
3. The library entrance from 2nd Street,
4. The school entrance from 6th Avenue,
5. The school entrance from 1st Street,
6. The north-east corner of the playground.

Appendix F

Raw Data and Subject Information

Raw Data and Subject Information

	Subject	Age	Sex	Stimulus* Order	Tactile Score	Verbal Score
Congenitally Blind	S1	22	M	T1-V2	18	12
	S2	22	M	T1-V2	15	8
	S3	24	M	T1-V2	6	10
	S4	16	M	V2-T1	17	13
	S5	19	F	V1-T2	12	9
	S6	31	F	V1-T2	15	9
	S7	14	M	T2-V1	7	9
	S8	64	F	T2-V1	14	9
Adventitiously Blind	S9	25	F	T2-V1	11	9
	S10	23	F	V1-T2	12	8
	S11	29	M	T2-V1	13	9
	S12	37	M	V1-T2	17	14
	S13	55	F	T1-V2	12	18
	S14	24	M	T1-V2	14	9
	S15	36	M	V2-T1	14	16

* The order of tactile and verbal maps presentation.